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AN ASSESSMENT OF WORKPLACE INJURY IN KENTUCKY'S COMMERCIAL LOGGING INDUSTRY

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CAPSTONE PROJECT PAPER

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Abstract

Objective: To identify demographic, operational, and task-related characteristics associated with increased frequency and severity of injury in Kentucky's commercial loggers.

Methods: Kentucky Master Loggers attending mandatory continued education courses completed a survey tool eliciting demographic and operational characteristics of their companies, and details of any on-site injury in the years 2012 through 2015 that led to medical costs, lost days or time, and/or decreased production. Associations to injury frequency and injury severity were assessed using logistic regression analysis.

Results: 86 Kentucky Master Loggers representing 66 of Kentucky's 120 counties reported 33 accounts of non-fatal logging injury. Master Loggers were full-time (75.29%) owner-operators (83.33%) with a diverse range of logging experience. The majority of operations employed just one to three loggers (70.93%) and operated using non-mechanized (43.53%) or partially mechanized (43.53%) harvesting systems. Of the 33 injured loggers, 22 (66.7%) had greater than three years of experience, and most were injured either while felling (42.42%) or delimbing/topping (24.24%). The average age of injured loggers was 34.6 years with a range age from 21 to 57 years. In multivariate analysis, non-mechanized and full-time operations were significantly associated with injury frequency, and age alone with injury severity.

Conclusion: Significant changes in industry practices have improved the overall safety for loggers in the United States, yet the fatality rate remains thirty times the national average. Reductions in risk can be solved with mechanization of logging operations, however, Kentucky companies are largely non-mechanized. Future studies of Kentucky's logging community should focus on developing interventions based on the internal characteristics of individual loggers.

Introduction

In the United States, the logging industry has consistently been the most deadly occupation, with fatality rates far surpassing the national average. In the ten-year period between 1980 and 1989, twenty three percent of the country's 6,400 occupational fatalities came from the logging industry, where the average fatality rate was 164 deaths per 100,000 workers (NIOSH, 2012). This rate was twenty-three times the all industry rate of seven deaths per 100,000 workers. In the past four decades, industry standards and mechanization of manual processes have decreased the fatality rate from a high of 192.1 per 100,000 in 1986, to 109.5 per 100,000 in 2014 (BLS, 2014). Today, the logging industry has a shrinking workforce, and in 2014 the seventy-seven deaths represented just 1.6 percent of U.S. occupational fatalities, however, the fatality rate has not decreased at the same pace of the country, now thirty-three times the national average of 3.3 per 100,000 workers. (BLS, 2014).

Occupational fatalities are extensively documented in the United States (BLS, 2014). Employers have eight hours to alert the Occupational Safety and Health Administration (OSHA), who investigates all work-related deaths. Other reports from police, coroner, state, and National Institute for Occupational Safety and Health, may provide extensive documentation of a death. From these sources, national studies can analyze and compare fatality rates to other industries. Non-fatal workplace injuries, however, are not documented in this extensive manner. OSHA injury and illness logs, workers compensation claims, and hospital discharge records are the most common source for studies of injury, however, with the logging industry, they are exempt from record keeping and non-claimed or treated injuries prevent a complete understanding of injury in this industry.

In the five years between 1992 and 1997, Kentucky loggers represented only 3.7 percent of the workforce, however, they had the third highest number of fatalities out of all fifty states (Sygnatur, 1998). The purpose of this study is to reveal the underlying risk of non-fatal injuries in Kentucky's logging workforce, severe and non-severe, and to generate new hypotheses that will direct attention to the dangerous aspects of the job and improve safety for the thousands of loggers in the state.

Literature Review

A literature search was conducted using PubMed, Google Scholar, and ResearchGate using the key words; *logging fatality, logging injury, occupational morbidity and mortality, forestry mechanization, workplace fatality, and forestry morbidity and mortality.* The search was limited to articles and resources printed in English.

Data Sources

Each year the Bureau of Labor Statistics (BLS) disseminates statistical data on occupational fatality and injury in order to support public and private decision making. Data are collected from the Survey of Occupational Injuries and Illnesses, which contacts a random sample of employers from each industry. The mandatory survey requires employers to report incidents from their OSHA 200 injury and illness log. A major concern of reliability arises from OSHA partial exemption 1904.1, stating that any company employing ten persons or less is not required to keep injury and illness logs, or report non-fatal incidents involving less than three employees (OSHA, 2001). Many small businesses fall under this exemption, and may cause the survey to underestimate the true rate of injury in many industries. According to the University of Kentucky Department of Forestry, the average number of employees per Kentucky logging company is three employees.

An all industry study by Shannon (2002) found that over forty percent of persons eligible for workers compensation did not submit a claim, causing significant concern for the underestimation of true risk using workers compensation data. Of sixteen variables, injury severity was most strongly related to claim submission. Even of those requiring medical attention, forty percent did not file a claim, and thirty percent of those requiring time off did not file a claim (p. 471). The high rates of non-claimed injuries in the workers compensation system challenge the internal and external validity of injury studies using this data source.

In 1998, a mailed survey was distributed to certified loggers in West Virginia to determine the number of non-fatal, logging related injuries. The survey had a thirty percent response rate, and of the loggers, forty-two reported at least one injury. The leading cause of injury was being struck by a falling limb or tree, and the most common body part injured was the leg, knee or hip. This study was specific to the cause and type of injury sustained, and the Personal Protective Equipment (PPE) worn by the logger. While the survey successfully collected the type of injury and body part injured, it failed to identify specific determinants that would allow further analysis of factors leading to logging injury (Helmkamp et al., 2014).

Age and Experience

Several risk factors can be attributed to increased logging-related injury including personal characteristics, work organization, physical environment, machines, tools and protective equipment. Age and experience have been identified as reliable predictors of both injury frequency and injury severity. A study published by Wang (2003) showed that the number of accidents, non-fatal and fatal, decrease step-wise by increasing age and years of experience. The proportion of fatal to non-fatal injuries, however, rises as age and experience increase (p. 275).

The injury incidence rate increases with age potentially due to the survival effect, as the number of older logger decrease and the remaining are overworked (Slappendel, 1993). The higher injury rate and injury severity can also be attributed to a decline in physical stamina and capability. Slappendel states that in logging, "physiological overloading may begin at 35 and reach a fully unacceptable level at age 55" (p. 23).

Mechanization

According to the NIOSH, twenty-three percent of work fatalities in a ten-year period between 1980 and 1989 occurred in the logging industry. Of these 1,492 deaths, ninety percent could be attributed to falling trees, limbs, snags and logs, and the majority of loggers were fellers, limbers, buckers and choker setters (NIOSH, 1995). In the 1970's and 80's, the logging industry was undergoing a technological transformation following the introduction of mechanical harvesters. These cabbed tractors and machines increased efficiency, combining the processes of felling, limbing and bucking into a single mechanized process. The first mechanized harvesters appeared in 1970's Europe and became a staple in the industry. A variety of harvesters are available on the market, however, due to cost, they remain out of budget for many companies. Logging operations that transitioned from non-mechanized to mechanized processes also experienced a significant decline in the number of injuries on their worksites (Bell, 2001). A study by LaFlamme and Cloutier (1988) found that the total number of occupational accidents decreased by fifty-five percent in companies using mechanized cutting processes. Similar studies of the changes in logging injury rates found that the use of a feller-buncher decreased a company's injury claims from 19.4 to 5.2 per 100 workers. Specifically, 'struck-by' injury claims decreased from 10.1 to 1.9 per 100 workers (Bell, 2001).

Protective Equipment

In non-mechanized operations, Personal Protective Equipment decreases the risk of injury by half (Slappendel, 1993). Recommended PPE for loggers includes safety boots, hardhat, gloves, hearing protection, eye protection, chaps, protective clothing, and face protection. Surveyed forestry workers have stated that elements of PPE can interfere with information flow to the operator, increase physiological strain, restrict movement, and cause discomfort, and for these reasons are often not worn (p. 24). In a survey by Helmkamp (1999), loggers were asked how often they wore individual elements of PPE. Responses varied by each piece of equipment. For example, eighty-two percent of loggers stated they always wear safety boots, however, many elements such as eye protection received a fifty-three percent 'always' ranking (p. 971).

In non-mechanized operation, the feller has the most dangerous role. Of 780 logging fatalities between 1992 and 2000, seventy percent occurred while felling and limbing (Scott, 2004). The feller uses a chainsaw and other tools to fall trees in a desired direction, optimizing recovery and minimizing potential hazards. Due to the high-risk role, and chainsaw use, fellers are recommended to wear all elements of PPE, including chaps and face shields.

Methodology

Study Population

Kentucky State Law KRS 149.330 states that a trained Kentucky Master Logger (KML), "must be on site and in charge of every commercial logging activity." To obtain a KML designation, a logger must complete a three-day training program and six hours of continue education training every three years to retain their status. Continuing education courses are held monthly across the state. The purpose of the Kentucky Master Logger program is to "enhance the loggers ability to operation efficiently within the framework of constantly changing

environmental and safety regulations." Each company designates their own Master Logger, whom is often an owner or supervisor.

There are currently 2,335 full and part time loggers employed in Kentucky. The Bureau of Labor Statistics characterizes loggers as predominantly white, with a median age of 44.9 years (BLS, 2014). In Kentucky, the typical logging company is non or partially mechanized, with an average of three employees.

Study Design

This study is an ongoing descriptive, hypothesis generating, cross-sectional pilot study using primary data collected by a survey tool. The survey uses variables identified from previous studies of logging injury and fatality. It was developed in coordination with Dr. Jeffery Stringer, Kentucky Master Logger Program Director and Forestry Specialist at the University of Kentucky Department of Forestry.

The survey was administered to Kentucky Master Loggers (KML) obtaining their required continuing education credits. Information specific to the Master Logger, such as personal experience and ownership, was requested first. The survey then called for details on the company's operation processes, counties logged, types of mechanized units, number of full-time, part-time, and seasonal employees. To quantify injury, Master Loggers were asked to indicate the number of persons injured in the past three years leading to medical costs, lost days or time, and/or decreased production. If the KML indicated any number of injuries on the previous question, they were then asked to list the injuries within six fields, beginning with most severe. Demographic information, PPE use, years of experience, length of missed work, role during injury, and method of injury were requested on each injured logger.

Surveys were administered over the course of four months in five locations across the state. Eligibility criteria required the injury to have occurred in the years of 2012-2015 in the state of Kentucky. Several injury accounts were not included in the analysis due to the date of injury and location outside the state. Participants were provided a letter detailing the purpose of the study and a statement of their anonymity. They were ensured verbally of their ability to opt-out of the survey at any point. No compensation was offered, and the University of Kentucky's Institutional Review Board approved all survey materials. Page one of the survey can be found in Figure 1.

Analysis

Univariate, bivariate, and multivariable logistic regression analyses were conducted using SAS software, version 9.4 (SAS Institute; Cary, NC, USA). A geographic analysis was performed using ArcGIS mapping software version 10 (ESRI, Redlands, CA, USA).

Two outcomes of interest, injury occurrence and injury severity, were used in separate analyses. Injury frequency was assessed using categorical variables specific to the Master Logger and Logging Company. A secondary variable, 'severity,' was created to illustrate injury severity. Injuries in which loggers missed less than one week of work were categorized as 'less severe,' and those who missed greater than one week, 'more severe.' Descriptive statistics, shown in table's 1a and 1b present the categorical variables specific to the separate outcomes of interest. Bivariate analysis by outcome variable was conducted to show the relationships between the covariates and outcomes of interest. Variables such as years at current company, month of injury, and injury description were omitted, due to limited sample size in the categories.

Further analysis of injury frequency and injury severity was conducted using logistic regression. Models were developed using predictor criterion from several previous studies. The

model of injury outcome and employer traits includes operation system, employment type, and number of persons on the job site. Logistic regression analysis of severity and injured logger traits was performed using the binary variables of age, experience and role. The variables were selected as covariates for the model based on their statistical significance in bivariate analysis and significance in previous studies.

A geospatial analysis was conducted to depict the density of counties represented by the survey respondents. Master Loggers were asked to list all counties in which they work and most listed three to four counties. The density map of counties represented is located in Figure 2.

Results

Data were collected from 89 Kentucky Master Logger surveys, of which 26 (29%) recorded one or more logging injury accounts. There were 37 total injuries recorded, 11 of which came from 5 surveys containing two or more injuries. Eligibility criteria required loggers to work within the state of Kentucky, and 3 Master Loggers were excluded because they indicated out of state residence, and no Kentucky counties logged. Four logging injuries that occurred prior to 2012 were also excluded. The following results describe the analysis of the eligible 86 Kentucky Master Logger survey responses and 33 injury accounts. On average each survey location yielded 17.2 eligible survey responses; Caldwell (n=19), Carter (n=19), Clay (n=18), Grayson (n=15), and Knox (n=15). Presented in Figure 2, 66 of Kentucky's 120 counties were represented from survey responses. Descriptive statistics of the Kentucky Master Logger and operation are presented in Table 1a, and characteristics of the injured logger in Table 2a. Results from bivariate logistic regression analysis in Tables 2a and 2b, include unadjusted odds ratios, 95% confidence intervals p-values to provide associations among covariates to injury frequency, and injury severity.

Master Logger, Operation and Injury Frequency

Master Loggers (n=86) were full time (75.29%) owner operators (83.33%) representing a diverse range of experience. Logging companies employed 1 to 3 full-time loggers (70.93%) and no seasonal or part time worker (60.24%). Operations used either non-mechanized (43.53%) or partially mechanized (43.53%) harvesting systems compared rather than fully mechanized systems (12.94%). Results from bivariate logistics regression are presented in Table 2a. Frequency of injury was significantly associated with the full-time employment status (p=0.037) and the non-ownership status of the Master Logger *(*p=0.007). Full-time employees, part-time or seasonal employees, operation system, and mechanized units were not significantly associated with the frequency of injury. Table 3a presents the results from a multivariable logistic regression model for injury frequency. Adjusting for all other covariates in the model, non-mechanized operation system (p=0.085) and full-time employment status (p=0.066) were nearly statistically significant in association with injury frequency. The variable, persons on job site (p=0.113), was included in the final model due to its precedent in previous literature (Slappendel, 1993). Loggers working at an operation that was non-mechanized had 2.32 times the odds of injury as those at partially or fully mechanized operations (95% CI [0.89, 6.05]). Full-time operations had 3.55 times the odds of injury compared to part-time loggers (95% CI [0.92, 13.68]).

Injured Logger Severity

Injured loggers were all white males with a mean age of 34.6 years, median age of 30 years and a range of 21 to 57 years. Of the 33 eligible injuries, 14 (42.42%) occurred during felling and 8 (24.24%) during delimbing and topping. Most loggers were injured from being struck by an object such as a limb tree or snag. Bivariate analysis using the created variable

severity, indicated that only the loggers age had a significant association with injury severity. Loggers less than 35 years of age are less likely to experience as severe injury compared to those older than 35 (p=0.027). Table 3b presented results from multivariate logistic regression model including the variables age, experience, and role. Adjusted for all other variables, age < 35 years was found to decrease the odds of injury severity (AOR=0.08, 95% CI [0.01,0.77]). The variables in the model were included due to the ongoing nature of the study, and the significance of the variables from multiple literature sources.

Discussion

Due to the limited information available on fatal logging injury, this pilot study's aim was to gain a greater understanding of the factors leading to logging injury and the characteristics of the logger that increases injury severity. Although the respondents represent a small portion of the state's logging workforce, the results depict the unique risks faced by Kentucky loggers and allows for more specific hypotheses to be generated.

This study is the first of its kind to assess injury frequency and injury severity using the characteristics of the Master Logger, company, and injured logger. The analyses performed in this study are only possible through direct survey data, as all other sources are unable to provide these variables in aggregate form. The results from this ongoing study are preliminary, and an increased number of survey responses will improve the ability of the study to generate more conclusive findings.

The Kentucky logging industry is unique from many states because the majority of operations are full-time, but employ few workers. The majority of loggers in the state use a combination of mechanical units in a partially mechanized system, or no mechanized units at all. Harvesting systems have long been associated with injury frequency. Though not found to be

statistically significant, non-mechanized operations were more likely to have an injury in comparison to mechanized ones. Full-time logging operations were also found to have a greater frequency of injuries in comparison to par-time. A full-time logger may be pressured to work quickly, and may be more willing to take risks in comparison to a part-time logger, but this difference could simply be due to the full-time workers increase exposure to the risk.

In correlation with other studies of logging injury and fatality, this study found that the role of the logger is one of the greatest predictors of injury frequency and injury severity. Of the 33 injuries recorded in this study, 14 were a direct result from felling. Injuries sustained by felling are likely to result from a limb or tree impact to the head. A study by McLeod (2015) indicated that the average feller is between 35 and 55 years of age with greater than 10 years of experience, however, the risk of injury was highest among loggers ages 16 to 24, with under 2 years of experience (p. 483). The average age of injured feller in this study was 28.17, of which 42.86% missed greater than 1 week from their injury. Delimbing and topping was the second most frequent cause of injury, but arguably the most dangerous. Of the 7 injuries recorded from those delimbing and topping, four were unable to work for greater than one month, and one had to leave the workforce permanently.

An association between age and injury frequency and severity has been previously identified by literature. The average age of injured loggers from this study was 34.6 years falls directly on 35 year age threshold of increased injury severity suggested by Slappendel (1993). From the bivariate analysis of injury severity, loggers older than 35 were more likely to experience injuries that lead to greater time lost. This statistically significant predictor may speak to the increased recovery rate of older workers.

Limitations

This study is an ongoing hypothesis generating pilot study and limitations arise from the small sample size acquired from the number of participants. Each covariate in the study was comprised of multiple categories, and the lack of statistical power limits the ability to detect differences within and among variables. There is also a concern for the potential of recall bias of injuries reported by the Master Logger. The validity of this study relies heavily on the ability of the Master Logger to account employees' and coworkers' injuries over a period of several years. Due to state law, the Master Logger's presence is required during any logging activity, and is therefore they represent the best source for injury recall second only to the individual logger. The potential for misclassification exists, as several surveys indicated multiple roles for the logger during one single injury account. Despite these limitations, this ongoing study contributes important insight to the factors influencing injury frequency and injury severity.

Recommendations

Previous studies of logging injury and fatality have shown significant evidence supporting the use of mechanized harvesting practices to reduce risk and improve efficiency (Bell, 2001, Laflamme & Cloutier, 1988). Kentucky logging companies are small, and the high cost of mechanization presents a barrier, that is not financially feasible. For Kentucky loggers, who primarily work full-time in non-mechanized processes, the most significant predictor of injury severity is age. Further investigation of this population should compare loggers to a similar workforce so that specific characteristics can be isolated. This study demonstrates that future direction should focus on the internal characteristics of the logger rather than the external traits of the operation.

Conclusion

Significant changes in logging practice have increased safety for loggers in the United States, yet logging remains the country's most dangerous industry with a fatality rate thirty times the national average. While fatal accidents are well documented, the current understanding of the risk leading to non-fatal logging injuries is incomplete.

This study found that the operation system and employment status of the logging company are the most important factors leading to injury frequency, and the age of the logger is the most significant factor for injury severity. Previous studies and industry recommendations suggest the most effective way to decrease injury risk is to invest in mechanized processes, an action that most Kentucky logging companies have not taken. The high cost of machines and small size of operations are the likely reason for Kentucky companies remaining largely non-mechanized.

Future research should focus on the individual characteristics of loggers so new safety recommendations may be developed. Logging is perilous work, and despite the risk, is essential to our society. In order to decrease the immense risk to the thousands of Kentucky loggers in this vital industry, greater attention and efforts to improve safety to the individual logger must be warranted.

Figure 1. Survey tool given to Kentucky Master Loggers

An Assessment of Logging Injuries and Factors Influencing Their Occurrence

Survey Date LOGGING INDUSTRY | Location:

Master Logger Information

Primary KY County / Counties Logged (County in which you work most often)

Are you the owner/operator of your organization?
☐ No ☐ Yes

Part-Time or Full-Time Logging Operation
☐ Full Time ☐ Part Time

How many years have you worked for/owned your current operation/company? _____

Years of experience logging (Personal)
☐ 1 – 5 ☐ 6 - 10 ☐ 11 – 15 ☐ > 15

Total number of persons working on job site
☐ 1 – 3 ☐ 4 – 6 ☐ 7 – 9 ☐ 10+

Operation System
☐ Non-Mechanized
☐ Partially Mechanized
☐ Fully Mechanized (> 75% felling and delimbing by machine)

Number of part-time/seasonal workers?
☐ None ☐ 1 – 5 ☐ 6 – 10 ☐ > 10

Do you commonly use a mechanized feller?
☐ No ☐ Feller Buncher ☐ Cut to Length Machine

In the past 3 years how many persons in your operation have experienced workplace injury that has led to medical costs, lost days or time, and/or decreased production on site?
☐ None ☐ 1 – 2 ☐ 3 – 4 ☐ 5 – 6 ☐ 7 – 8 ☐ > 8

Has there ever been an incident on your job site that has resulted in a fatality?
☐ No ☐ Yes

Incident information

Please answer the following questions about the injuries on your work site.

Injury 1.

Age_____ Gender _____ Race _____ Month of Injury _____ Year of Injury_____

Brief description of the injury (i.e. broken arm, concussion etc.)

PPE worn at time of incident
☐ Hard hat ☐ Chaps
☐ Eye protection ☐ Steel toe boots
☐ Ear protection

Years of Logging Experience
☐ Less than 1 year
☐ 1 to 3 years
☐ Greater than 3 years

Length of Missed Work due to injury
☐ None ☐ More than 1 week ☐ Fatality
☐ 1 to 2 days ☐ More than 1 month
☐ 3 to 5 days ☐ Forced to change line of work

Role During Injury
☐ Operating mechanical harvester ☐ Felling
☐ Operating Skidder ☐ Delimbing / topping
☐ Operating Dozer ☐ Bucking
☐ Operating Loader ☐ Choker Setting
☐ Equipment Maintenance ☐ Other_____

Description of Injury Occurrence (Check all that apply)
☐ Dead (snag) tree fall ☐ Struck by log loading or unloading
☐ Live Tree Fall ☐ Struck by log (other)
☐ Limb Fall ☐ Run over by machine
☐ Chainsaw ☐ Equipment roll over
☐ Fall / Slip / Trip ☐ Mechanical / Repair
☐ Other _____ ☐ Mounting / Dismounting

Injury 2.

Age_____ Gender _____ Race _____ Month of Injury _____ Year of Injury_____

Brief description of the injury (i.e. broken arm, concussion etc.)

PPE worn at time of incident
☐ Hard hat ☐ Chaps
☐ Eye protection ☐ Steel toe boots
☐ Ear protection

Years of Logging Experience
☐ Less than 1 year
☐ 1 to 3 years
☐ Greater than 3 years

Length of Missed Work due to injury
☐ None ☐ More than 1 week ☐ Fatality
☐ 1 to 2 days ☐ More than 1 month
☐ 3 to 5 days ☐ Forced to change line of work

Role During Injury
☐ Operating mechanical harvester ☐ Felling
☐ Operating Skidder ☐ Delimbing / topping
☐ Operating Dozer ☐ Bucking
☐ Operating Loader ☐ Choker Setting
☐ Equipment Maintenance ☐ Other_____

Description of Injury Occurrence (Check all that apply)
☐ Dead (snag) tree fall ☐ Struck by log loading or unloading
☐ Live Tree Fall ☐ Struck by log (other)
☐ Limb Fall ☐ Run over by machine
☐ Chainsaw ☐ Equipment roll over
☐ Fall / Slip / Trip ☐ Mechanical / Repair
☐ Other _____ ☐ Mounting / Dismounting

Figure 2. Density map of Kentucky Counties logged by operations of Kentucky Master Loggers responding to Survey

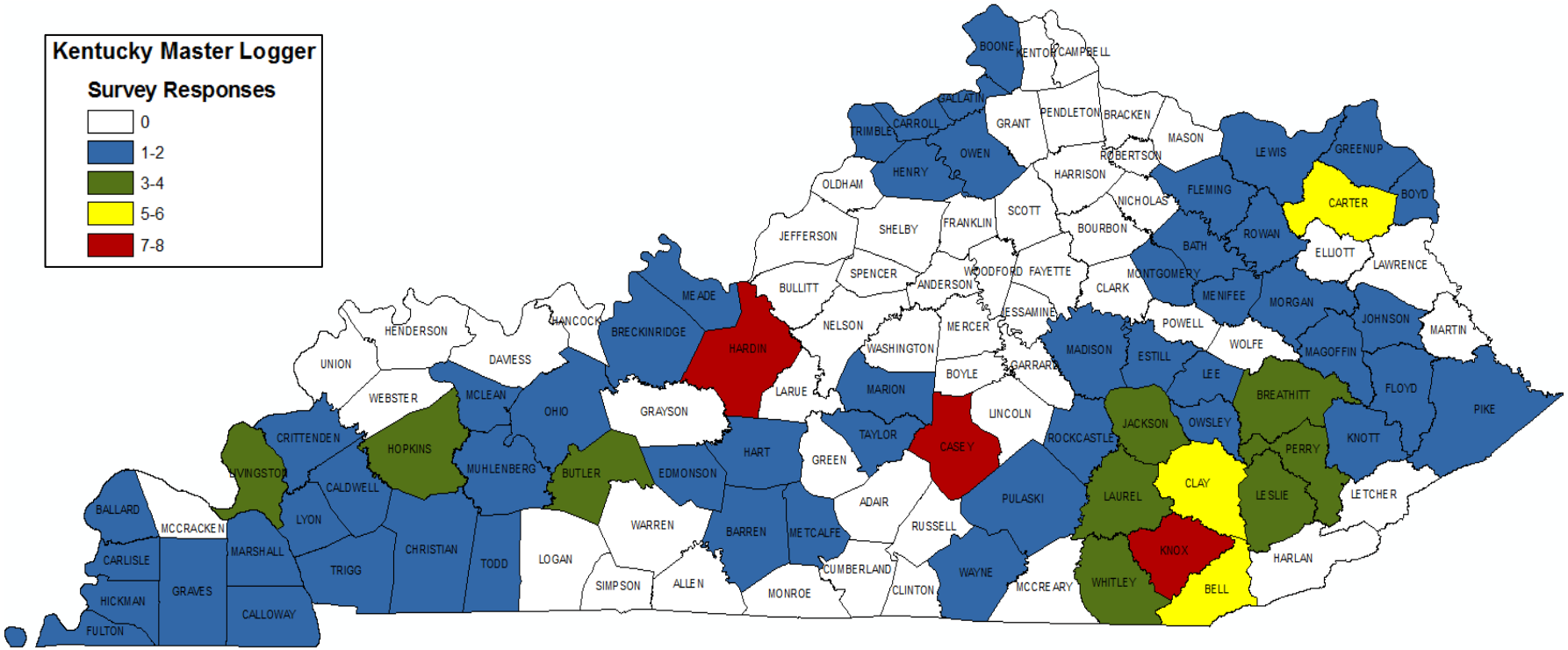

Table 1a. Characteristics of Kentucky Master Loggers and Operation

Master Logger			Operation		
Characteristic	N	(%)	Characteristic	N	(%)
Employment Status			*Number of Persons On Job Site*		
Full-Time	64	(75.29)	1-3	61	(70.93)
Part-Time	21	(24.71)	4-6	23	(26.74
Missing	1	-	>6	2	(2.33)
Owner Operator			Missing	0	-
Yes	70	(83.33)	*Number of Seasonal/Part-time Worker*		
No	14	(16.67)	None	50	(60.24)
Missing	2	-	1-5	31	(37.35)
Years of Experience			6-10	1	(1.21)
1-5	22	(27.16)	>10	1	(1.21)
6-10	10	(12.35)	Missing	3	-
> 10	49	(60.49)	*Operation System*		
Missing	5	-	Non-Mechanized	37	(43.53)
Years at current company			Partially Mechanized	37	(43.53)
1-5	36	(45.75)	Fully Mechanized	11	(12.94)
6-10	6	(12.35)	Missing	1	-
> 10	35	(45.45)	*Mechanized Units*		
Missing	9	-	None	65	(79.27)
			Feller Buncher	12	(14.63)
			Cut to Length Machine	5	(6.10)
			Missing	4	-
			Injured Workers 2012-2015		
			None	58	(67.44)
			1-2	25	(29.07)
			3-4	3	(3.49)
			> 4	0	(0.00)
			Missing	0	-

Table 1b. Characteristics of injured loggers

Characteristic	N	(%)
Age		
< 20	0	(0.00)
20-34	18	(56.25)
35-49	9	(28.13)
50-65	5	(15.63)
> 65	0	(0.00)
Missing	1	-
Gender		
Male	33	(100)
Female	0	(0.00)
Missing	0	-
Race		
White	32	(100)
Non-White	0	(0.00)
Missing	1	-
Years of Experience		
< 1	7	(21.21)
1-3	4	(12.12)
>3	22	(66.67)
Missing	0	-
Month of Injury		
January	2	(6.90)
February	2	(6.90)
March	2	(6.90)
April	0	(0.00)
May	2	(6.90)
June	1	(3.45)
July	8	(27.59)
August	4	(13.79)
September	4	(13.79)
October	2	(6.90)
November	2	(6.90)
December	0	(0.00)
Missing	4	-
Year of Injury		
2012	0	(0.00)
2013	2	(6.67)
2014	9	(30.00)
2015	19	(63.33)
Missing	3	-

Characteristic	N	(%)
Length of Missed Work Days		
None	10	(31.45)
1-2 days	1	(3.13)
3-5 days	7	(21.88)
> 1 week	6	(18.75)
> 1 month	7	(21.88)
Permanent	1	(3.13)
Fatality	0	(0.00)
Missing	1	-
PPE Use during Injury		
None	3	(9.09)
Some	27	(81.82)
All	3	(9.09)
Missing	0	-
Role During Injury		
Bucking	1	(3.03)
Choker Setting	3	(9.09)
Delimbing/Topping	8	(24.24)
Equipment Maintenance	1	(3.03)
Felling	14	(42.42)
Operating Dozer	1	(3.03)
Operating Loader	1	(3.03)
Operating Harvester	3	(9.09)
Operating Skidder	1	(3.03)
Other	0	(0.00)
Missing	0	-
Injury Description		
Chainsaw	5	(16.13)
Dead (snag) Tree fall	3	(9.68)
Equipment Rollover	0	(0.00)
Fall/Slip/Trip	4	(12.90)
Limb Fall	9	(29.03)
Live Tree Fall	5	(16.13)
Mechanical Repair	1	(3.23)
Mount/Dismounting	0	(0.00)
Run Over by Machine	0	(0.00)
Struck by Log	2	(6.45)
Other	2	(6.45)
Missing	2	-

Table 2a. Bivariate analysis of Master Logger/Operational Characteristics and Injury Frequency

Characteristic	Injury		No Injury				
	N	(%)	N	(%)	Crude OR	95% CI	*p*-value
Employment Status							
Full-Time	29	(40.28)	43	(59.72)	4.05	(1.09, 14.99)	0.037
Part-Time	3	(14.29)	18	(85.71)	1.00	-	
Owner Operator							
Yes	19	(26.39)	53	(73.61)	1.00	-	
No	12	(60.00)	8	(40.00)	4.18	(1.48, 11.80)	0.007
Number of Persons On Job Site							
1-3	20	(30.30)	46	(69.70)	1.00	-	
> 3	13	(46.42)	15	(53.57)	1.99	(0.80, 4.95)	0.140
Number of Seasonal/Part-time Workers							
None	20	(28.99)	49	(71.01)	1.00	-	
1-5	7	(46.67)	8	(53.33)	1.41	(0.68, 6.70)	0.469
6-10	4	(66.67)	2	(33.33)	12.33	(0.83, 28.92)	0.027
Operation System							
Non-Mechanized	17	(41.46)	24	(58.54)	1.74	(0.73, 4.19)	0.205
Mechanized (Partial/Full)	15	(28.85)	37	(71.15)	1.00	-	
Mechanized Units							
None	20	(28.99)	49	(71.01)	1.00	-	
Feller Buncher	7	(46.67)	8	(53.33)	2.14	(0.69, 6.70)	0.188
Cut to Length Machine	3	(60.00)	2	(40.00)	4.90	(0.83, 23.92)	0.079

Table 2b. Bivariate Analysis of Injured Logger Characteristics and Severity

Characteristic	Less Severe < 1 Week Missed Work		Most Severe > 1 Week Missed Work				
	N	(%)	N	(%)	Crude OR	95% CI	*p*-value
Age							
< 35	13	(72.22)	5	(27.78)	0.17	(0.04, 0.81)	0.027
≥ 35	4	(30.77)	9	(69.23)	1.00	-	
Years of Experience							
0-3	7	(70.00)	3	(30.00)	0.47	(0.09, 2.10)	0.296
>3	11	(50.00)	11	(50.00)	1.00		
PPE Use During Injury							
None	2	(66.67)	1	(33.33)	1.00		
Some	16	(61.54)	10	(38.46)	1.06	(0.09,12.50)	0.963
All	0	(00.00)	3	(100.0)	11.67	(0.19,735.9)	0.245
Role During injury							
Operating Machine	5	(71.43)	2	(28.57)	1.00	-	
Felling	8	(57.14)	6	(42.86)	1.88	(0.27, 13.20)	0.528
Delimbing/Topping	1	(14.29)	6	(85.71)	15.0	(1.03, 218.3)	0.048

Table 3a. Logistic regression of injury outcome from employer traits

Characteristic	Adjusted OR	95% CI	*p*-value
Operation System			
Non vs. Partial/Full Mechanization	2.32	(0.89, 6.05)	0.085
Employment Status			
Full vs. Part Time	3.55	(0.92, 13.68)	0.066
Number of Persons on Job Site			
> 3 vs. 1-3	2.19	(0.79, 6.07)	0.113

Table 3b. Logistic regression of injury severity from injured logger traits

Characteristic	Adjusted OR	95% CI	*p*-value
Age			
< 35 vs. ≥ 35	0.08	(0.01, 0.77)	0.029
Experience			
0-3 years vs. >3 years	0.33	(0.04, 2.74)	0.307
Role			
Felling vs. All Others	0.16	(0.01, 1.76)	0.129

Appendix A. Abbreviations and Definitions

Bucking	Process of cutting felled and delimbed trees into logs at specified lengths
Choker setting	Attaches a choker, or a noose of strong cable, to each downed log, then hooks the tail of the choker to another cable or hook so the log can be pulled toward the road
Cut to length	Mechanized harvesting system in which trees are delimbed and cut to length directly at the stump.
Dozer	"Bulldozer," or continuous tracked tractor with a front blade
FACE	NIOSH Fatality Assessment and Control Evaluation
Feller buncher	Harvester with an attachment that can rapidly cut and gather several trees before felling them
Feller	Logger cutting down trees
Fully mechanized	Greater than 75% of felling and delimbing is done by machine
Harvester	Vehicle use for felling, delimbing and bucking trees
KML	Kentucky Master Logger
Limbing	Process of removing branches from a fallen tree
Loader	A tractor with a front-mounted bucket
Non-mechanized	Felling and delimbing are done entirely by chainsaw
OSHA	Occupational Safety and Health Administration
Partially-mechanized	Some felling and delimbing is done by machine but less than 75%
Skidder	Vehicle used to pull cut trees out of the forest from stump to landing
Snag	A dead or dying tree still standing, but typically unstable

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